LOW CONTAMINANT WIPER

TECHNICAL FIELD

This invention relates to the manufacturing of fabric wipers, in particular, wipers that release fewer and/or less offensive particulate contaminants while nonetheless exhibiting good sorbency and strength.

BACKGROUND OF THE INVENTION

Wipers may be made from knitted, woven or non-woven fabrics of materials such as polyester and the like. The typical manufacturing process begins with drawing and texturing continuous filament yarn. The textured yarn is knitted or woven to construct a fabric, and the fabric is washed or scoured to remove spinning oils. The fabric may be chemically modified in order to improve its wettability and performance. The fabric is then dried in a "tenter frame" oven to remove moisture and heat set the fabric. Heat setting dissipates stress in the polyester fibers and stabilizes the fabric.

Next, the fabric is cut into wipers, typically 9 inch by 9 inch squares. The wipers may remain unlaundered or may be washed in a cleanroom laundry, employing special surfactants and highly-filtered and purified water, to reduce the contamination present on the fabric. After washing, the wipers may be packaged dry in air-tight plastic bags, or pre-saturated with a suitable solvent before being packaged.

These wipers are utilized for a number of different applications, including cleaning within cleanrooms, automotive painting rooms and other environments in which particulate contaminants are undesirable. Each

different application emphasizes certain standards these types of wipers should attain. For example, for wipers utilized in cleanrooms, stringent performance standards must be met. These standards are related to sorbency and contamination, including maximum allowable particulates, unspecified extractable matter and individual ionic contaminants. The standards for particular contaminant release are especially rigorous and various methods have been devised to meet them. For example, Paley et al., U. S. Pat. No. 4,888,229 (incorporated by reference) describes a wiper having fused borders, the sealed edge of the wipers being present to reduce contamination caused by small fibers. Diaber et al., U. S. Pat. No. 5,229,181 (incorporated by reference) describes a knit fabric tube, only two edges of which must be cut and sealed, thereby reducing the contamination caused by loose fibers from the edges. Paley et al., U.S. Pat. No. 5,271,995, (incorporated by reference) describes a wiper for a cleanroom environment that has reduced inorganic contaminants through the use of a specific yarn, namely "nylon bright". Reynolds, U. S. Pat. No. 5,069,735 (incorporated by reference) describes a procedure to cut the fabric into pieces using a hot air jet in the range of 600 to 800 °F to melt the fibers, forming a sealed edge product with reduced loose fiber contamination.

Despite advantages made in reducing particulate contamination release from cleanroom wipers, further reductions in particulate release are, nevertheless, highly desirable.

SUMMARY OF THE INVENTION

According to one aspect of the invention, a low contaminant wiping cloth suitable for a wide range of applications is provided. The wiper meets substantially all of the specifications for use in cleanrooms, particularly those specifications for Class 100 clean rooms and below.

According to another aspect of the invention, a cleanroom wiper having a high liquid sorbency capacity is provided.

According to still another aspect of the invention, a wiping cloth is provided which has substantially stable edges that do not undergo substantial particulate generating fracture upon application of tensile stresses applied during normal use.

According to still another aspect of the invention, a wiping cloth is provided which incorporates yarns of substantially reduced inorganic ion content so as to reduce the effects of any particles which may be released.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will now be described by way of example only, with reference to the accompanying drawings which constitute a part of this specification and in which:

FIG. 1 is an elevation plan view of one embodiment of a wiper according to the present invention;

FIG. 2 is a view taken along line 2-2 in FIG. 1;

FIG. 3 is an elevation plan view of another embodiment of a wiper according to the present invention;

FIG. 4 is an elevation plan view of yet another embodiment of a wiper according to the present invention; and

FIG.5 is a view taken along line 5-5 in FIG. 4.

While the invention has been illustrated and will hereinafter be described in detail in connection with certain potentially preferred embodiments and practices, it is to be understood that the foregoing general description as well as the following detailed description and accompanying drawings are exemplary and explanatory only and in no event is the invention intended to be limited thereby. On the contrary, it is intended that the present invention shall extend to all alternatives, modifications and equivalents as may embrace the broad principles of this invention within the true spirit and scope thereof.

DESCRIPTION OF PREFERRED EMBODIMENTS

Reference will now be made to the drawings, wherein to the extent possible, like elements are designated by like reference numerals throughout the various views. All of the United States patents cited within the specification are hereby incorporated by reference in their entirety as if fully set forth herein.

According to the potentially preferred practice, the wipers of the present invention may be constructed from a multiplicity of woven or knitted yarns of polyester fiber, preferably fibers of poly(ethylene terephthalate).

Such yarn is preferably a continuous filament polyester yarn although other yarn types and constructions may likewise be utilized if necessary. It is contemplated that yarns having a wide variety of denier and filament count characteristics may be employed. Examples of useful yarns may include those having a denier to filament ratio of about 0.1 to about 10, incorporating deniers of about 15 to about 250. A wide range of fabric weights may be employed in the wipers of the present invention. Typically, the fabrics used for cleanroom wipers have a weight of about 1 to about 9 ounces per square yard, and more preferably about 3 to about 7 ounces per square yard.

If desired, it is contemplated that the yarn employed in the fabric may be a textured polyester yarn. Such yarns are commercially available and their manufacture is well known to those of skill in the art. Briefly, partially oriented yarn (POY) is modified by crimping, imparting random loops, or otherwise modifying the bulk or surface texture of the yarn to increase cover, absorbency, resilience, abrasion resistance, warmth, insulation and/or to improve aesthetics. A general description of the texturing process may be found in the Encyclopedia of Textiles, Fibers, and Non-woven Fabrics, Encyclopedia Reprint Series, Ed. Martin Grayson, pages 381 – 398, John Wylie and Sons (1984) and Dictionary of Fiber and Textile Technology, Hoechst Celanese (1989). During the texturing process the yarn is preferably not heated above a temperature of 300°F and is generally not heated above about 225°F.

According to one potentially preferred practice of the present invention, once formed, the fabric is preferably subjected to washing and heat setting

procedures as described in U. S. Patent 6,189,189 to Morin et al. (incorporated by reference). In particular, the fabric is preferably dried and heat set at a temperature from about 180 ° F to about 300 ° F and more preferably from 200 ° F to 275 ° F and most preferably from 225 ° F to 265 ° F. The heat set temperature is preferably set at a temperature higher than that which the yarns have previously experienced. Such heat set treatment is believed to improve performance criteria applied to wipers for use in cleanroom environments including sorbency, as well as both the quantity and size of generated particles.

In general, it is desired that cleanroom wipers exhibit high levels of sorbency while generating low levels of particulate contaminants during use. Moreover, it is desired that those particulate contaminants which may be generated have low levels of inorganic ionic constituents such as metallic constituents which may influence the performance of small scale integrated circuitry.

It has been recognized that during use of a wiper, the edges of the wiper may give rise to a disproportionately high level of particulate generation. It is theorized that such disproportionate particulate generation arises from the breaking of fiber elements along the high-energy surfaces at the perimeter edges of the wiper. To alleviate this problem it has been proposed to fuse the borders of the wipers either just along the edge or in a substantially solid fusion zone extending a distance inwardly from the edge towards the interior of the wiper. Such fused zones may be imparted by melting the fibers within the zones by use of energy delivered from a directional heat application

source. However, fused edges or extended borders may tend to reduce elasticity in those areas relative to the remainder of the wiper. Thus, upon a stretching of the wiper, the fused edges or extended borders may tend to undergo premature localized fracture thereby releasing potentially undesired particulate matter.

According to a first embodiment of the present invention as illustrated in FIG. 1, a wiper 10 formed of knitted polyester yarns is provided. While a knitted construction of substantially 100% polyester may be preferred, it is also contemplated that other constructions including woven and nonwoven constructions and other fibers including nylon and the like may also be utilized if desired.

As shown, the wiper 10 includes an interior wiping surface 12 and a multiplicity of perimeter edges. In the illustrated and potentially preferred embodiment the wiper 10 is of a substantially quadrilateral geometry such that the wiper 10 includes a first perimeter edge 14 and an opposing second perimeter edge 16 as well as a third perimeter edge 18 and a fourth perimeter edge 20 extending in a generally right angled relation between the first perimeter edge 14 and the second perimeter edge 16. While the wiper 10 is illustrated as being substantially square in configuration, it is likewise to be understood that the wiper 10 may take on any number of other geometries including by way of example only, and not limitation, a rectangular configuration or some other convenient multi-sided configuration such as a triangular, pentagonal, hexagonal, or octagonal geometry as may be desired.

As will be appreciated, the wiper 10 is cut from a much larger web of fabric having an extended length and a width sufficient to yield multiple wipers. According to a potentially preferred practice, the wiper 10 is cut from such larger web of fabric according to a pattern such that the first and second perimeter edges 14, 16 extend in the so called "cross-machine direction" disposed substantially transverse to the elongate direction of the fabric web. Correspondingly, the third and fourth perimeter edges 18, 20 are preferably cut substantially along the so-called "machine direction" of the fabric generally parallel to the elongate direction of the fabric web.

As illustrated, the first perimeter edge 14 and the second perimeter edge 16 extending in the cross-machine direction are each preferably provided along their length with a sealed edge 24, 26 formed by a hot knife or laser cutting operation so as to seal the fibers along the raw cut edge of the wiper 10. In addition, the first and second perimeter edges 14, 16 are each preferably provided with an inwardly extending discontinuous fused border 28, 30 extending inwardly from the adjacent sealed edges 24, 26 towards the interior wiping surface 12. As shown, the discontinuous fused borders 28, 30 are preferably made up of a multiplicity of discrete bond points 34, 36 at which thermoplastic fibers such as polyester forming the wiper 10 have undergone localized melting thereby fusing together upon resolidification.

It is contemplated that the bond points 34, 36 extending in the cross-machine direction may be applied in a predefined repeating pattern utilizing a patterned embossing element such as an ultrasonic horn operating on one side of the fabric forming the wiper 10 in opposing relation to a surface

patterned anvil disposed on the opposite side of the fabric forming the wiper 10 within a width corresponding to the desired width for the inwardly extending discontinuous fused borders 28, 30. Of course, other patterned fusion techniques may also be utilized such as using a patterned support on one side of the fabric and applying a hot ironing element across the opposing side so as to apply the series of bond points 34, 36.

According to the illustrated and potentially preferred practice, the discontinuous fused borders 28, 30 extending in the cross-machine direction preferably have a relatively narrow width in the range of about 0.3 mm to about 1.6 mm and will most preferably have a width in the range of about 1.0mm to about 1.4 mm although greater or lesser depths may likewise be utilized if desired. As shown, according to one embodiment, the bond points 34, 36 may be substantially rectangular in configuration arranged in a brick-like pattern within the discontinuous fused borders 28, 30 such that the length dimension of the bond points 34, 36 extends generally parallel to the outer sealed edges 24, 26. Of course, it is contemplated that any number of other geometric arrangements may be likewise be utilized including, by way of example only, and not limitation, discrete substantially circular bond points, elongate elliptical bond points, square bond points, and other geometries. Moreover, due to their discontinuous nature, the bond points may also be arranged in a pattern in the form of a message conveying icon such as a corporate logo, patent number or the like. According to the illustrated practice wherein the bond points are substantially rectangular in configuration, the rectangles forming the bond points are preferably in the range of about 0.75

mm wide by about 3 mm long and are spaced about 1 mm apart in defined rows. The rows are preferably about 0.5 mm apart with the bond points in adjacent rows being slightly offset from one another in another in a staggered relationship.

It is believed that the utilization of the discontinuous fused borders 28, 30 reduces the generation of particulate matter upon the application of tension in the direction parallel to such borders by allowing the force to be spread more evenly through the matrix formed by the interstitial areas between the bond points 34, 36 thereby reducing the concentration of force which may lead to the localized breakage of fibers.

It is contemplated that load distribution may be further enhanced by pre-stressing the wiper 10 in the cross-machine direction prior to introduction of the discontinuous fused borders 28, 30. According to one potentially preferred practice, pre-stressing of the fabric may be carried out by stretching the fabric forming the wiper 10 during the introduction of the bond points 34, 36 thereby essentially locking in a stretched relationship. Such stretching may be carried out by use of a stretching frame or by other means as will be well known to those of skill in the art. Upon release of the fabric following the introduction of bond points 34, 36 a portion of the extension is relieved within the body of the wiper 10 but the bond points 34, 36 serve to substantially lock in stretch along the perimeter edges 14, 16.

As shown, the third and fourth perimeter edges 18, 20 extending in the machine direction preferably have a slightly different configuration. As best seen by simultaneous reference to FIGS. 1 and 2, the perimeter edges 18, 20

extending in the machine direction of the wiper 10 are preferably formed by folding the edges inwardly so as to form double layer borders 38, 40. Inboard of the double layer borders 38, 40 melt fused attachment zones 48, 50 are applied to thereby seal the double layer borders 38, 40 in place. As shown, according to one embodiment, the attachment zones 48, 50 may be made up of a pattern of fusion bond points 44, 46 formed by localized patterned melting of polyester or other thermoplastic fiber constituent in the manner described above. However, if desired, the attachment zones 48, 50 may also be in the form of solid melt fused strips extending inwardly from the inboard edge of the double layered borders 38, 40.

The double layer borders 38, 40 which are preferably smooth and substantially free of fusion bond points provide an edge structure which is not substantially susceptible to fiber fracture upon stretching and is thus believed to promote the integrity of the edges during stretching thereby reducing the generation of particulates. The attachment zones 48, 50 (whether solid or discontinuous in nature) are preferably broad enough such that a stable fusion bond relationship is established. By way of example only, and not limitation, in the event that the attachment zones are made up of discrete bond points 44, 46 as shown wherein the bond points 44, 46 are of a substantially rectangular configuration having a width in the range of about 0.75 mm and a length in the range of about 3 mm arranged in an off-set brick pattern in rows approximately 0.5 mm apart, it is contemplated that at least about 3 and more preferably about 4 or more such rows are utilized. Of course other geometries for the bond points 44, 46 as described above in the

relation to the fused borders 28, 30 extending in the cross-machine direction may also be utilized if desired.

As with the bond points 34, 36 extending along the cross-machine direction of the wiper 10, it is contemplated that the bond points 44, 46 disposed along the machine direction may be applied by use of any suitable patterned melt fusion device including by way of example only, and not limitation, an ultrasonic bonding apparatus using a rotating patterned anvil wheel or a patterned heat sink support used in conjunction with an ironing heat source.

According to one practice, it is contemplated that the formation of the wiper 10 may be carried out in a highly efficient and automated manner by continuously slitting an elongate web of fabric to yield multiple parallel strips of desired width. This cutting may be carried out using a laser or hot knife to seal the lateral edges. The strips are conveyed along a travel path through an edge folding apparatus at which a blade or paddle element is used to continuously fold the lateral edges of the strips so as to form the desired double layer borders 38, 40. The strips are thereafter passed through ultrasonic bonding stations arranged generally transverse to the travel path of the strips at which the bond points 44, 46 forming the fusion zones 48, 50 along the lateral perimeter edges are applied. By way of example only, it is contemplated that the ultrasonic bonding stations used to form the bond points 44,46 within the fusion zones 48, 50 may be generally similar to the device illustrated and described in U.S. patent 6,001,442 to Rockwell, Jr. (incorporated by reference) incorporating elongated horns and rail-like

patterned anvils oriented in the direction of travel of the strips. The inwardly extending discontinuous fused borders 28, 30 extending in the cross machine direction are thereafter applied across the width of the segmented strips by ultrasonic bonding units incorporating an elongated horn and rail-like patterned backing anvil oriented generally transverse to the travel path of the strips. The wiper 10 is segmented from the strip by use of a hot knife or laser, which serves to form the sealed edges 24, 26. Of course, any number of other automated or manual techniques may likewise be utilized if desired.

As will be appreciated, the present invention is susceptible to a wide range of alternative constructions. By way of example only, one such alternative construction is illustrated in FIG. 3 wherein elements corresponding to those described in relation to FIG. 1 are designated by like reference numerals increased by 100. As shown, the embodiment of FIG. 3 is substantially identical to that of FIG. 1 except that the double layer borders 38, 40 have been replaced by extended discontinuous fusion zones 148, 150 which extend substantially to the adjacent perimeter edges 118, 120.

In FIG. 4 there is illustrated yet another embodiment of the present invention wherein elements corresponding to those previously described in relation to FIG. 1 are designated by like reference numerals increased by 200. As shown, in this embodiment, the double layer folded edge structures are applied along each of the perimeter edges 214, 216, 218, and 220. This configuration results in the occurrence of double layer borders 260, 262 extending in the cross-machine direction along the first and second perimeter edges 214, 216 with discontinuous fused borders 228, 230 disposed inboard

thereof as shown in FIG. 5. Such a configuration is believed to further reduce the potential for the generation of particulates during use of the wiping cloth 210. Of course, if desired, the discontinuous fused borders 228, 230 may be replaced by substantially continuous fusion zones such as strips extending inwardly from the double layer borders 260, 262.

Aside from the reduction in the potential for particle generation as the edges of the wiper are stretched, the present invention further contemplates that the relative impact of such particles may be reduced substantially through selection of the materials of construction forming the wiper. According to a potentially preferred practice, the wipers of the present invention are formed from polymeric fibers incorporating very low levels of inorganic additives. In particular, the fibers forming the wiper of the present invention are preferably formed of so-called "bright" or "clear" polyester. Such fiber is substantially free of titanium dioxide (TiO_2) or other metal-based opasifying agent as is normally used to impart the traditional brilliant white character associated with polyester. Titanium dioxide and other metallic ion compounds are prone to leeching into solution when placed in a highly acidic environment. In view of the fact that many electronic fabrication procedures utilize highly concentrated acid solutions such as sulfuric acid (H_2SO_4) it has been recognized by the applicants that it may be desirable to reduce the presence of such ionic constituents within any particles which may be generated so as to avoid the accumulation and potential concentration of such ions within cleanroom acid solutions which may be used a number of times.

According to the potentially preferred practice, the fiber forming the wiper according to the present invention is preferably characterized by a concentration of inorganic ionic constituents at a level such that upon complete combustion of the fiber, the remaining ash content is in the range of less than about 0.30% of the initial fiber weight and is more preferably in the range of about zero to about 0.1% of the initial fiber weight and is most preferably in the range of about zero to about 0.3% of the initial fiber weight. One such fiber which may be desirable in the formation of the wiper according to the present invention is believed to be available from E. I. DuPont de Nemours which is believed to have a place of business in Wilmington, Delaware.

Testing

The level of particulate generation associated with cleanroom wiper edges of various constructions has been determined by stretching a 6 centimeter segment of the wiper edge of interest to a length corresponding to the elongation occurring upon application of tension of 6 pounds force. This stretching takes place with the wiper edge held in the vertical position over a 14 cm funnel mounted on the end of an isokinetic probe linked to an airborne particle counter. The inverted wiper segment was stretched and held in tension for a period of 2 seconds and was removed while still taut. Resulting count of generated particles greater than or equal to about 0.3 microns was recorded upon stabilization of the counter.

The invention may be further understood by reference to the following comparative examples.

EXAMPLE 1

Cleanroom wiper style "A" having edge constructions substantially as illustrated and described in relation to FIGS 1 and 2 with double layer folded edges in the machine direction and discontinuous fused edges in the cross machine direction was formed from tightly constructed balanced knit fabric of double knit construction made up of 70 denier 36 filament polyester yarn with 41 wales per inch X 40 courses per inch and a weight of 3.7 ounces per square yard. Segments of both the double layer folded edges in the machine direction and the discontinuous edges in the cross-machine direction in thirty-one of the wipers were tested for particle generation under application of tension according to the testing procedure as described above. The results of such testing are set forth in Table 1.

EXAMPLE 2

A cleanroom wiper style "B" formed of fabric as described in Example 1 was formed having thermally sealed edges in both the machine direction and the cross-machine direction. Thermal sealing was carried out in accordance with the teachings of U.S. Patent 5,069,735. Edge segments in the machine direction and in the cross-machine direction in thirty-one of the wipers were tested for particle generation under tension according to the

testing procedure as described above. The results of such testing are set forth in Table 1.

EXAMPLE 3

A cleanroom wiper style "C" having inwardly extending fused edges as described in U.S patent 4,888,229 to Paley et al. in both the machine direction and the cross-machine direction was obtained from a commercial source. The fabric forming the wiper was made up of 70 denier 34 filament polyester yarn in a double knit construction with 37 wales per inch X 47 courses per inch with a weight of 4.2 ounces per square yard. Edge segments in the machine direction and in the cross-machine direction in thirty-one of the wipers were tested for particle generation under application of tension according to the testing procedure as described above. The results of such testing are set forth in Table 1.

EXAMPLE 4

A cleanroom wiper style "D" was formed having thermally sealed edges in both the machine direction and in the cross-machine direction. Thermal sealing was carried out in accordance with the teachings of U.S. Patent 5,069,735. The fabric forming the wiper was a double knit construction of 70 denier 36 filament polyester yarns having 43 wales per inch X 37 courses per inch and a weight of 3.52 ounces per square yard. Edge segments in the machine direction and in the cross-machine direction in

thirty-one of the wipers were tested for particle generation under application of tension according to the testing procedure as described above. The results of such testing are set forth in Table 1.

Table 1

Wiper Style	A Machine Direction	A Cross-Machine Direction	B Machine Direction	B Cross-Machine Direction	C Machine Direction	C Cross-Machine Direction	D Machine Direction	D Cross-Machine Direction
Average Particle Count Measurement	409	1357	3702	1433	2875	3731	2030	1598
High Particle Count Measurement	936	2205	5955	2754	6018	7173	3712	2601
Low Particle Count Measurement	84	203	1471	402	1020	1643	879	682
Standard Deviation	233	604	1455	556	1251	1634	721	614
Statistical Mean Lower Confidence limit (99%)	301	1078	3029	1176	2296	2975	1697	1314
Statistical Mean Upper Confidence limit (99%)	516	1636	4375	1690	3454	4487	2363	1882

This data is believed to confirm that the double edge construction of wiper style "A" results in a dramatic improvement in both the average and actual number of particles generated in tension over that which is believed to have been available heretofore. Likewise, in regions where a non-folded extended border zone is utilized, the inwardly extending discontinuous fused border edge construction of wiper style "A" provides much lower particle generation than the inwardly extending solid fused border of wiper style "C".

While the present invention has been illustrated and described in relation to certain potentially preferred embodiments, constructions, and procedures, it is to be understood and appreciated that such embodiments,

constructions, and procedures are illustrative and exemplary only and that the present invention is in no event to be limited thereto. Rather, it is contemplated that modifications and variations embodying the principles of the present invention will no doubt occur to those of skill in the art to which the invention pertains. It is therefore contemplated and intended that the present invention shall extend to all such modifications and variations as may incorporate the broad principles of the invention in the full spirit and scope thereof.